Future Flows

University of Maryland, College Park

Registration Number: M23

Team Members:

Bridget Stokes, Master of Landscape Architecture Candidate | 2022
Bryn Martin, Master of Landscape Architecture Candidate | 2022
Hannah Savio, Master of Landscape Architecture Candidate | 2022
Kelsey Moody, Master of Landscape Architecture Candidate | 2022
Ella Battish, Bachelor of Environmental Science and Technology Student | 2025
Anushka Tandon, Bachelor Environmental Science and Technology Student | 2025

Faculty Advisors:

Dr. Byoung-Suk Kweon, PLA, ASLA
Associate Professor, Department of Plant Science and Landscape Architecture

Dr. Peter May
Assistant Research Professor, Department of Environmental Science and Technology

Michael Carmichael
Stormwater Management Inspector, UMD Facilities Management

Acknowledgements:

Christopher Ho, P.E.
Campus Civil Engineer

Darwin Feuerstein
Site Projects Manager

Daniel Hayes, AIA
Architect / Campus Planner

Michael Furbish
President, Furbish

Paul Jester, PLA
Landscape Architect, J&G Landscape Design

Christopher D. Ellis, PLA, ASLA
Professor, Department of Plant Science and Landscape Architecture

Dennis Nola, PLA, ASLA
Assistant Director, Department of Plant Science and Landscape Architecture

Allen P. Davis
Professor, Department of Civil and Civil and Environmental Engineering

Daniel Patterson
GIS Analyst, Toole Design Group

Anna Dennis, PLA, ASLA, LEED Green Associate
Senior Associate, Design Collective

Vincent Yi
Landscape Designer, Rodgers Consulting

I. Abstract

The Future Flows Master Plan advocates for a strong new vision of flows on campus by limiting car traffic to the periphery of campus. Beyond improving the safety of pedestrians and drivers, this frees up space to reexamine healthy and beneficial flows of water on campus. To plan for future flows, the team examined conditions in the commuter and athletic portions of the North District of campus, which directly abuts Campus Creek and Paint Branch Stream, tributaries of the Anacostia River. Reimagining the way cars and pedestrians move through this part of campus creates opportunities to reconfigure the flow of people and water, transforming accessibility and leveraging ecological benefits. Inevitably, new infrastructure will be needed to accommodate UMD's growing population. UMD's continuing needs as a commuter-centric school need to work with, not against, the flows of water. Since part of the North District is within the Federal Emergency Management Agency (FEMA) floodplain, development options are limited. Existing infrastructure in the North District is quantifiably leading to the degradation of Campus Creek, rising temperatures due to heat island effect, high incidence of car accidents, deficient pedestrian safety, and the continuing facilitation of a car-centric campus. By examining current fluctuations in the movement of people and water, this master plan design will accommodate future flows through reconnection, revitalization, and restoration of the North District of UMD's campus.

II. Project Intro

UMD was founded as a land grant institution in 1862 to teach agricultural practices. UMD has grown to become a forerunner in science and engineering, but holds onto its roots in the field of agriculture. This evolution of the school has led to a unique merging of the two fields, and the school has made major contributions in environmental science research and technological advances that protect the environment and promote sustainability. The importance of sustainability and environmental protection to the fabric of UMD as an institution is demonstrated in the UMD Master Plan, which emphasizes UMD's goals to "realize and reveal the ecosystem service potential of the urban landscape" and to "increase the ability of the campus natural hydrologic cycle to deal appropriately with stormwater run-off"(University of Maryland (UMD), 2011). UMD's Master Plan demonstrates commitment to changing the way stormwater is managed, but there seems to be a disconnect between ideas and implementation. Future Flows aims to stress the need for a complete mindset shift. UMD has made slow progress, and it is time for ecosystem services and pedestrian safety to become priorities.

Actions taken at UMD have wide-reaching effects. According to the Maryland Department of the Environment (MDE), Maryland is home to numerous streams and rivers that ultimately drain into Chesapeake Bay, the largest inland estuary in the United States. These streams and the Bay not only provide drinking water, food, economic opportunities, and water for irrigation, but also a home for a diverse ecosystem" (MDE, 2021). Future Flows proposes radical, yet tenable solutions to reduce the adverse impacts of development on stormwater runoff from impervious surfaces and leverage transportation mode shifts to meet current and future flow needs. The project addresses the harmful effects of current infrastructure by restoring ecological habitats, revitalizing campus through green infrastructure, and reconnecting UMD's disorganized transportation system around the peripheral edges of campus. By studying prior development patterns, current UMD research projects, data for trends in population growth, and expected changes in the intensity and variability of storms due to climate change, Future Flows plans not only for the influx of people and water, but for periods of drought, as well.

The team collaborated with university staff, alumni, and landscape architects from local firms over the duration of the project. The team worked closely with the campus planner, engineer, and landscape architect to understand current plans and incorporate realistic ideas for the future, and conferred with UMD professors about campus projects in the landscape architecture and environmental technology department to generate ideas for continuing to push the project forward after the project team graduates. The team worked withFacilities Management to understand current stormwater facilities and infrastructure. Additionally, the team communicated with the UMD Department of Transportation to acquire data about parking and circulation on campus. Consultations with professionals outside of the UMD community helped the team generate design ideas and gain insight into stormwater management techniques that are currently being employed by local firms in Maryland to save and restore local water systems including the Anacostia River and Chesapeake Bay.

Fig. 1- Map of the Anacostia River Watershed

III. <u>Site Context</u>

UMD is located in Prince George's County, Maryland, within the Anacostia River watershed (Figure 1). Studies done by the District Department of Energy and Environment (DOEE) concluded that the Anacostia River was one of the most polluted rivers in the nation (District Department of Energy and Environment (DOEE), 2020), and that "elevated concentrations of contaminants… from industrial, urban, and human activities are present in sediment throughout the Anacostia River, posing a potential risk to humans or aquatic wildlife." Green infrastructure can counterbalance the effects of urbanization by managing and treating stormwater at its source, before it flows into major bodies of water.

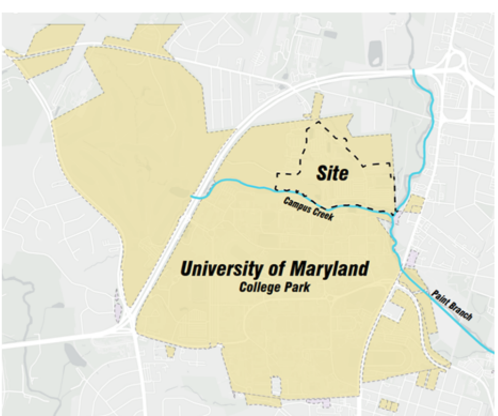


Fig. 2- Map of site

The site covers an area of 66 acres in the North District of UMD's campus (Figure 2). Located off of University Ave- a central gateway onto campus- the North District is heavily car-centric. The parking lot used for shuttle buses is currently in the floodplain, requiring the buses to be moved when there is heavy rainfall and the parking lot may flood. Future Flows transforms the bus parking lot into a floodable field, relocating bus parking to a designated part of the new parking garage near the multi-modal transportation plaza.

UMD Athletics is a major component of UMD culture and community. The parking lots in the North District surrounding UMD's stadium, the Xfinity Center, are used for tailgating on basketball and football game days. Tailgating is an event that brings alumni, faculty, students, and families together and strengthens lifelong connections to the University.

IV. Existing Conditions

Land Cover

Fig. 3- A high percentage of site is impervious surface

Impervious surfaces currently cover 37 acres (56%) of the site. 29 acres (44%) of the site is impervious paving, including 20 acres of surface parking. 7 acres (11%) is covered by buildings on site. Permeable surfaces make up 29 acres (44%) of the site (Figure 3).

Soil Analysis

The site is predominantly Type D soils with high levels of clay, poor infiltration rates, and high runoff potential. These soils are found along the steep slopes along the banks of the Paint Branch Stream, which is within the 100 year flood plain and prone to flooding and erosion. The results of the USDA Web Soil Survey indicate that the soil along Paint Branch Stream and Campus Creek is heavily eroded due to steep slopes and frequent flooding, while much of the disturbed urban soil is poorly drained due to high levels of clay and the presence of large expanses of impermeable surfaces (US Department of Agriculture, 2021).

Hydrology

Fig. 4- Topography and current hydrological flow

Surface water flows in this area of campus run primarily from northwest toward the southeast, contributing to Campus Creek along its north bank. Stormwater drains accommodate many parking lots and other impervious areas. Four outflows flow directly into Campus Creek

The FEMA 100 year flood zone overlays 20 acres (30%) of the site. The Shuttle Bus Facility, Field Hockey and Lacrosse Complex, parking lot 11b, half of the Xfinity Center Visitor Lot, and portions of Paint Branch Drive are within the floodplain. Of particular concern is the built infrastructure and plans for future development within the floodplain (Figure 4).

Parking and Circulation

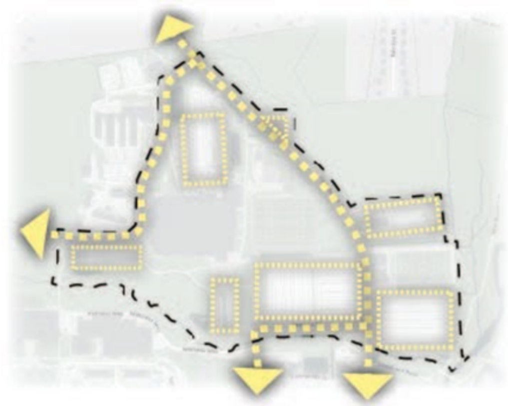


Fig. 5- Parking and vehicle circulation

The UMD North side of Campus is car centric with few designated walking paths for students (Figure 5). There are large spans of impervious surfaces to accommodate parking for commuters. 14,873 people currently commute to campus and 20 acres of the site are devoted to impermeable parking lots with 2,941 parking spaces for cars and 70 parking spaces for buses. There are five areas that are used as bus stops for the UMD shuttle. These stops are generally used as inter-campus transport buses.

V. Problems To Be Solved

Problem 1: Outdated stormwater management

A main concern in the North District is the large area of impervious surface,a detrimental factor for stormwater runoff and pollutant loading. This is particularly true because the site is within an urban area and most of the impervious surfaces are large spans of parking lots. The many vehicles that park in the North District discharge oil, gas, antifreeze, and other toxic waste that enter outdated storm drains without being treated and flows directly into Campus Creek, then into larger water bodies. In addition, the outdated stormwater management facilities can overflow during periods of heavy rain or snowfall.

Problem 2: Degraded and undervalued ecological areas

The North District of campus has a high land use density with a high percentage of impervious surface. Density rises with urbanization and development, leading to an increase in overland flow, magnitude and frequency of storm flows, channel efficiency, and pollution load delivered by runoff. High percentage of impervious surface in this area indicates that high pollutant loads are running into Campus Creek and subsequently into the Anacostia River. In addition, high levels of development in the area indicates modifications to drainage networks. The team gathered quantitative data on both the pre-development and post-development drainage networks in order to mimic pre-development drainage networks to the highest degree possible. In the North District, modifying past and current development trends can restore the undervalued fragile ecosystems and improve outdated stormwater management methods contributing to erosion and flooding of Campus Creek, an amenity that is not currently realized.

Problem 3: Low walkability and lack of multi-modal transportation priorities

The North District is car centric with few safe and comfortable walking paths for students. Vehicles, bikes, and scooters share the roads with no separate bike lanes. Though this area of campus is dominated by car traffic, pedestrian volume remains high. Traffic congestion and lack of pedestrian zones has led to numerous vehicular accidents and injuries. In the past seven years, there have been twenty pedestrian crashes on the UMD campus; two were incapacitating/disabling, and eight possily incapacitating. There have been ten bicycle crashes on campus, with two possibly incapacitating injuries and three non-incapacitating injuries. There have been two bicycle crashes within the site, and one pedestrian sustaining a possibly incapacitating injury (Maryland State Police, 2021). By improving circulation on campus, UMD aligns their mission with Vision Zero, Prince George's countywide strategy to eliminate traffic-related serious injuries and deaths by 2040 (Prince George's County Department of Public Works, 2021).

VI. Goals and Approaches

The goals for this project are not mutually exclusive; they complement each other to meet the overarching goal of creating a more sustainable and pedestrian-oriented North District. As a result, approaches to meeting the project goals are interwoven; several approaches achieve multiple goals.

Goal 1: Revitalize stormwater strategy by improving floodplain connectivity, decreasing stormwater runoff, and reducing pollution loading.

The approach to revitalization of the North District includes the repurposing of underutilized impervious spaces into recreational spaces with stormwater management elements, the addition of green roofs to existing and proposed structures, construction of an academic building on stilts above the floodplain, installation of underground cisterns, and construction of bioswales along the complete streets. The introduction of floodable fields falls into the categories of green infrastructure and ecological restoration. Future Flows transforms the bus parking lot into a floodable synthetic turf field, relocating bus parking to the new parking garage near the multi-modal transportation plaza.

Goal 2: Restore visibility and aesthetic value of Campus Creek and other undervalued ecological areas

Campus Creek channel restoration, riparian buffer plantings, a new Campus Creek Trail, increased tree canopy cover, and Regenerative Stream Conveyance outfall step pools are the project approaches to both revitalize and restore the North District through green infrastructure and ecological restoration. Future Flows proposes long term maintenance along Campus Creek that includes invasive removal, tree plantings, removal of debris from stormwater facilities on a regular basis, and continued water quality testing. Long term maintenance and riparian buffer planting could be interwoven with environmental education. Environmental studies classes could take place along Campus Creek, which could become a living laboratory and model of sustainability. Students could study the ecosystems that would thrive along a restored Campus Creek.

A walking trail along a restored Campus Creek allows for an immersive experience in nature, which has been proven to improve mood and attention, and relieve depression and anxiety (UMD School of Public Health, 2021). This is of particular importance on a college campus. The Mayo Clinic reports that “up to 44% of college students reported having symptoms of depression and anxiety” (2021). In a time when students have additional pressures and stresses due to COVID-19, immersion in nature can offer a place to “get away”. UMD already has a “new and burgeoning movement” to promote health and wellness through immersion in nature, based on the “premise that time spent in nature is therapeutic and contributes to personal contentment” (University of Maryland School of Public Health, 2021).

Goal 3: Reconnect campus community by providing safe and enjoyable circulation

31% of students and faculty currently commute to campus. Future Flows focuses on finding methods to make this part of campus safer and more pedestrian-friendly as local and global initiatives shift toward reducing the carbon releasing use of fossil fuels, and as UMD continues to phase out the use of vehicles on campus. The viability of Future Flow’s bold approach to redirect vehicle traffic to the periphery of campus, allowing passage only for emergency vehicles and buses, is supported by data showing a decline in people commuting to campus. The number of commuters has decreased by 1.4% since 2018 due to campus initiatives such as Carpool Permit discounts, Green Driver discounts, and Smart Commute (DOTS, 2021) and will continue to decrease with the construction of the Purple Line, a light rail connector that will have stops directly on campus. Future Flows builds on these initiatives by constructing a new parking garage on the outskirts of campus to consolidate personal car use and provide retrofit opportunities as parking demand decreases in the future. An adjacent multi-modal plaza provides bicycle, scooter, and skateboard rentals and parking and is proximate to shuttle bus stops, all allowing people to park, then easily get to their destination using a more eco-friendly mode of transportation.
Future Flows creates a traffic flow that is similar to a traffic circle; vehicles can circle campus, and enter at designated areas to park. Future Flows demonstrates the feasibility of this model; vehicles can enter campus to reach the tailgating field, and are then redirected out of campus via a traffic circle. Buses and emergency vehicles can continue over the bridge into campus as needed. This circulation pattern considers accessibility by allowing passage of emergency vehicles and buses over an existing bridge that traverses Campus Creek. The team foresees this new traffic pattern completely altering the way people think about transportation by creating new habits. Data indicates that the use of cars is declining; Future Flows envisions a new normal, where people do not rely on cars as a primary mode of transportation within campus.

Future Flows was also designed in accordance with changes and opportunities currently underway on campus. The Purple Line, which is currently under construction, will run through the middle of campus, effectively bisecting campus into two separate areas on the north and south ends. When construction on the Purple Line is completed, vehicles will no longer be able to drive directly through campus.

New federal fuel-efficiency standards are also a driving force in changing the way people commute to campus. UMD expects that “by 2025, these standards alone may reduce carbon emissions by 53,000 MTCO2e from just commuters' trips to and from campus (SustainableUMD, 2021). UMD studies are showing trends that support the reduction of need for parking. An increasing number of staff and students working remotely, continued construction of nearby off-campus housing, and the introduction of the Purple Line are projected to contribute to the decline in the number of people commuting to campus via personal vehicle(SustainableUMD, 2021).

VII. Solutions

Environmental

Stormwater

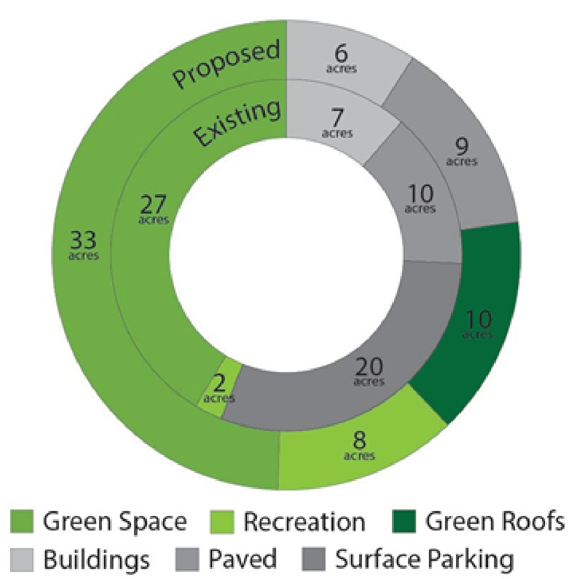
Future Flows will reduce the average stormwater runoff on site by 132%. More than 222,000 cubic feet of water is absorbed from bioretention, and on average, a 2.5" rain event is treated entirely on site.

	Total Suspended Solids (lbs)	Total Phosphorus (lbs)	Total Nitrogen (lbs)
Existing	1102	1.75	15.6
Proposed	476	1.14	5.5
Percent Reduction	57%	35%	65%

The EPA has established TMDLs for the Chesapeake Bay for Total Suspended Solids (TSS), Total Phosphorus, and Total Nitrogen. Using the Simple Method (*Simple method - hydrocad stormwater modeling*) given Pollutant Concentrations from Source Areas, pollutant loads were calculated for existing and proposed conditions for these three pollutant types (i-Tree Eco). Bioretention ponds on the site would further reduce the amount of these pollutants in surface runoff. Riparian buffer planting will intercept 710 cubic feet of runoff/year.

Trees and shrubs planted by Future Flows will help to reduce runoff by an estimated 709 cubic feet a year with an associated value of $47. Avoided runoff is estimated based on local weather from the user-designated weather station. In Future Flows, the total annual precipitation in 2016 was 41.8 inches (i-Tree Eco).

Land Cover



The Future Flows redesign is 23% impervious, a 33% reduction from existing conditions.

Future Flows eliminates 20 acres (1800 vehicle parking spaces and 70 bus spaces) of surface parking and constructs a covered parking garage with a green roof and solar panels. Reduction of impervious surface also leads to better water quality due to reduced pollutant loads and higher amount of stormwater runoff treated on site. Of the existing land uses within the 100 year flood plain, 9 acres are parking lots. Removal of this area and replacement with more congruous land uses improves infiltration and eliminates the potential for pollutants to flow directly into the waterways in case of flooding.

Riparian Buffer
Future Flows will also increase native riparian buffer planting along the creek to 5.17 acres, a 68% increase, thereby restoring approximately .5 miles of streamside forest habitat to reduce erosion and improve water quality. Future Flows will employ regenerative stream conveyance step pools to prevent future erosion.

Green Roofs
Future Flows takes into account the fact that green roofs capture and slow the flow of water but also contribute to waterborne pollutants due to compost and chemicals needed to maintain the vegetation (A. Davis, personal communication, December 3, 2021). Removal of toxic chemicals is done through a series of treatments before the stormwater enters Campus Creek. After rainfall filters through green roofs, it flows into surrounding bioretention cells that will reduce the pollutant load. From there it will overflow into swales, which promote infiltration while conveying any remaining runoff toward Campus Creek. Silva cells along the proposed pedestrian path through the middle of the North District allow for additional infiltration and filtering of stormwater. A green wall along the side of the proposed basketball practice stadium will provide additional treatment of stormwater as it travels from the green roof to the underground cistern.

Future Flows adds a total of 10 acres of extensive green roofs to the site, including to an existing parking garage, and as features of the proposed academic building, basketball stadium and new parking garage. The four proposed green roofs capture and treat 30,000 cubic feet of stormwater runoff. Two of the green roofs also include solar panels, which have various renewable energy benefits. The new green roofs on the basketball practice court will drain into a cistern located beneath the tailgating field, capturing 7500 gallons of stormwater runoff for non-potable use on campus.

Tree Plantings
Future Flows will plant 245 native trees. The gross sequestration of Future Flow trees is about 1,300 pounds of carbon per year with an associated value of $107. Future Flows trees will store approximately 3.86 tons (Figure 10) (i-Tree Eco).

Heat Island
In addition to reduced pollutant loads, reduction of impervious and low albedo surfaces on site lowers the average surface temperature by approximately 10%. The current surface temperature of vegetated pervious surface on site is 68.1 °F; average surface temperature of asphalt is 93.5°F; and average surface temperature of concrete is 77.7°F, for an overall surface temperature average of 79.7 °F over 55 acres. Future Flows proposed changes would lower the average surface temperature to 72°F.

Social

Circulation

The solutions suggested by Future Flows would lead to a transformation of the campus culture and community on a fundamental level. Currently, there are no bike lanes on campus, making biking through the site a dangerous and harrowing experience. The sidewalk is disconnected or nonexistent along several roads within the project scope, causing pedestrians to cross busy streets to continue walking to their destination. Future Flows' solution reconnects circulation for pedestrians and realigns traffic flow to reduce congestion.

Complete Streets

Future Flow's inclusion of complete streets also creates a safer traffic flow and would add nearly 2,300 linear feet of bike lanes and more than 2,500 linear feet of pedestrian trail. The new 1,540 foot pathway that traverses the site north to south from the multi-modal plaza to Campus Creek is a shared use path- a two-way pathway that can be used by both bicyclists and pedestrians- to further improve safety measures.

Recreation

A main goal outlined in the UMD Master Plan is to increase recreation area (UMD Master Plan, 2011). Future Flows increases recreation area within the site from approximately 2 acres to 8 acres while incorporating green infrastructure to protect and restore Campus Creek. Future Flows addresses this need while also introducing green infrastructure and innovative stormwater management. Future Flows transforms the largest parking lot in the North District into a turf field that can be used for tailgating and recreation on an alternating basis. On game days, the field can be used for parking and tailgating. When it is not being used for temporary parking, the fields can be used for recreational activities.

Public Outreach and Education

The master plan includes several opportunities for public outreach and education. UMD is already working with Prince George's County on future sustainability projects, including green infrastructure and biking paths (SustainableUMD, 2021). The proposed boardwalk connects directly to an existing path along the Paint Branch and would provide an invitation for the community to comfortably permeate the campus boundary.Public outreach could invite surrounding elementary and high schools to conduct outdoor education classes that study the Regenerative Stream Conveyance and other stormwater management facilities. There are nine academic departments in the School of Agriculture and Natural Resources alone, with over 200 courses each semester. Countless students, faculty, and members of the community could benefit from a restored Campus Creek that offers spaces for hands-on, interactive outdoor learning.

Economic

Tree Planting Benefits

Urban forests have a "replacement value based on the trees themselves and functional values based on the functions the trees perform" (i-Tree Eco). Native trees planted in Future Flows have a replacement value of $44,900 and carbon storage value of $659. Trees planted have annual functional values of $107 for carbon sequestration, $47.40 for avoided runoff, and $70.50 for pollution removal (i-Tree Eco).

Reconnection of Floodplain

Repurposing land uses within the 100 year floodplain and reconnecting the Campus Creek to its floodplain will reduce potential impact of future floods. A large area consisting of residential and business properties located in the city of College Park, outside of campus boundaries, lie within the floodplain. "A 2018 study found that from 2007–2013, homes inside the metro area's 100-year floodplain had a market value that was 3.5%–12.2% lower than that of similar homes outside the floodplain"(American Flood Coalition, 2021) . 7% of Maryland properties have a 26% risk of severe flooding over the next 30 years. Evidence also suggests that homes near the 100-year floodplain lose value after flooding. Flooding can dismantle utilities, hinder access to emergency services and transportation, damage sewer systems, and negatively impact the overall economic prosperity of an area (First Street Foundation, 2021).

VIII. Design Performance (Calculations)

The Future Flows site can be divided into six distinct drainage areas. Maryland law states that "Environmental Site Design (ESD) [must] be used to the maximum extent practicable (MEP) to control stormwater from new and redevelopment." (ESD Process and Computations, 2020). The ESD values were calculated for each drainage area for existing and proposed conditions using the following formula:

ESDv = (Pe)(Rv)(A)/12

Where:

ESDv = Runoff volume

PE = Rainfall target

Rv = the dimensionless volumetric coefficient; equal to 0.05 + 0.009(I)

Where:

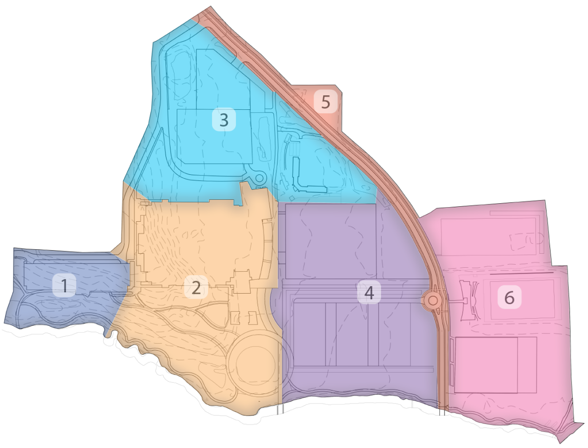
I = percent impervious cover

A is the drainage area

Existing Conditions

Drainage Area	% Impervious (I)	Rainfall Target (PE)	Runoff Coefficient (Rv)	Drainage (Sq.Ft)	ESDv (Cu. Ft)
1	46	1.5	0.462	187308	10952
2	54	1.7	0.534	666468	51759
3	50	1.7	0.504	588060	41292
4	54	1.7	0.536	644688	49020
5	67	1.7	0.657	200376	18713
6	62	1.7	0.608	601128	52758

ESD Calculations



The ESD values improved significantly for each drainage area due to the significant decrease in impervious cover in the proposed condition. These improvements were bolstered by specific, quantified green infrastructure practices. Drainage areas one and six posed problems for decreasing ESD that were lessened in the proposed conditions but not eliminated. Drainage area one contains a large existing structure that was retrofitted with a green roof, but will still result in runoff. The resultant runoff will enter a bioretention cell, which is a large as practicable due to its proximity to the riparian buffer. Drainage area six is limited by poorly infiltrated soils and it's location within the 100 year floodplain. Our approach here was to eliminate as much impervious surface as possible, which reduced but did not eliminate surface runoff from drainage area 6. While a 1.7" storm in the existing conditions would result in significant runoff, on average, the proposed conditions should be able to accommodate a 2.5" storm with minimal runoff in all but two drainage areas.

Proposed Conditions

Drainage Area	Impervious % (I)	Rainfall Target (PE)	Runoff Coefficient (Rv)	Drainage (Sq.Ft)	ESDv (Cu. Ft)	Green Roofs (Cu. Ft)	Bioretention (Cu. Ft)	Cistern (Cu. Ft)	Total Runoff (Cu. Ft)
1	47	1.5	0.469	187308	11101	5015	5612	-	475
2	53	1.7	0.526	666468	51018	-	116276	-	-65257
3	39	1.7	0.397	588060	32499	16646	40811	-	-24959
4	34	1.7	0.354	644688	32387	5241	33055	1000	-6909
5	57	1.7	0.559	200376	15924	-	18706	-	-2781
6	20	1.7	0.226	601128	19631	2729	7853	-	9049

Tree Planting Benefits

It is estimated that trees remove 20 pounds of air pollution (ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 2.5 microns (PM2.5), and sulfur dioxide (SO2)) per year with an associated value of $70.5 (Figure 12) (i-Tree Eco).

IX. Integration with Regional Plans

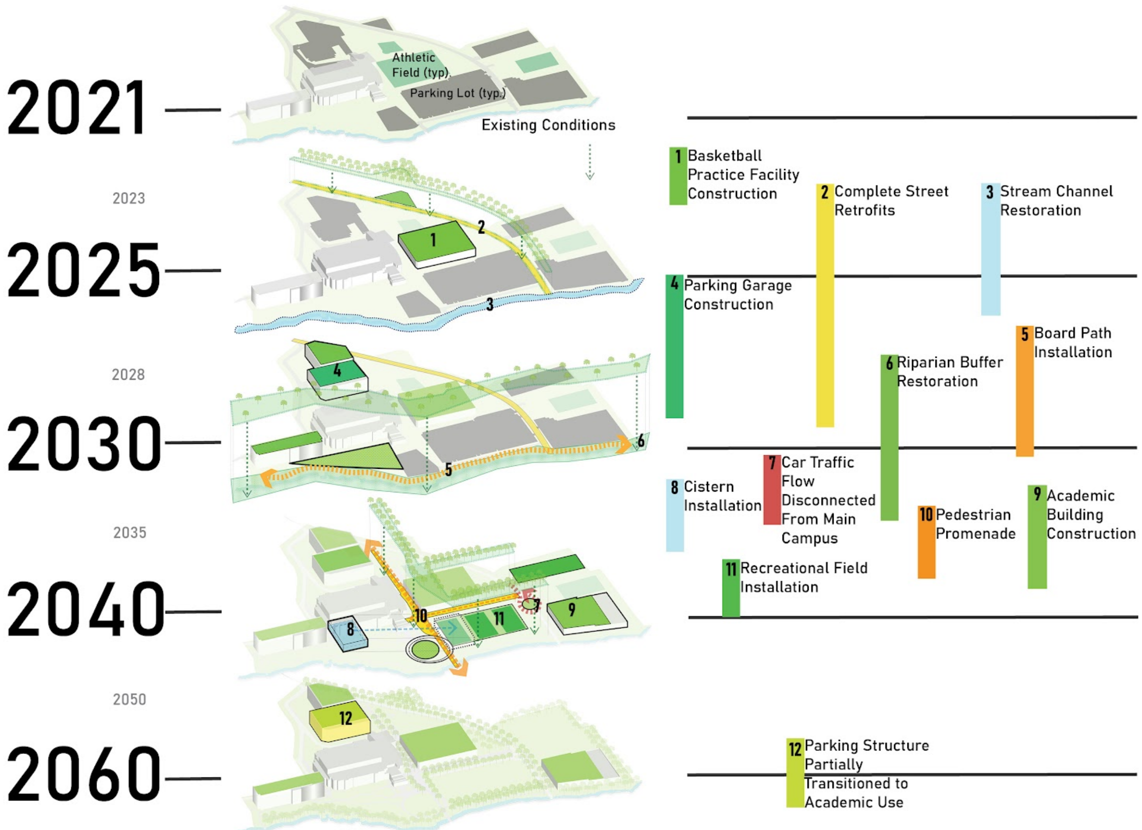
Maryland is unique in the fact it is part of six distinct physiographic provinces: (1) the Atlantic Continental Shelf Province, (2) the Coastal Plain Province, (3) the Piedmont Plateau Province, (4) the Blue Ridge Province, (5) the Ridge and Valley Province, and (6) the Appalachian Plateaus Provinces (Maryland Geological Survey, 2021). Due to the variety of land types, Maryland is home to a vast amount of ecosystems and species, making state planning and environmental laws in Maryland especially important. Land consumption is growing at three times the rate of population growth in Maryland, losing farmland and forest at a rate that is not sustainable (PlanMaryland, 2011). State planners will need to "accommodate the 1 million additional residents Maryland is projected to have by 2035, while at the same time better protecting the Chesapeake Bay and saving more than 300,000 acres of farmland and forest" (PlanMaryland, 2011). Unfortunately, State planning and development priorities are heavily influenced by politics. The current administration has prioritized local land use control, making coordinated efforts for stormwater management and development in sensitive areas more difficult. As a State University, UMD is uniquely situated to coordinate efforts on the regional and local levels and act as a driving force and model of sustainable development and green infrastructure. UMD states that it will "continue to explore the potential of Public-Private Partnerships to help catalyze appropriate local economic and physical development and strengthen relationships with existing businesses and institutions" (UMD Master Plan, 2011).

The goals and solutions outlined in Future Flows align with the Maryland Commission on Climate Change (MCCC), which recommends that Maryland achieve net-zero greenhouse gas emissions economy wide by 2045 and should prepare Maryland residents and infrastructure for the impacts of climate change such as rising sea levels, increased flooding, and changing weather conditions

Future Flow's goals and values also align with Plan 35, Prince George's County Planning Department's most recent comprehensive plan, which outlines a 20 year vision for future growth (Prince George's County Planning Department, 2014). It designates eight Regional Transit Districts to focus planned growth and emphasizes the importance of natural resource conservation and public coordinated efforts to plan for environmental and economic prosperity.

X. Phasing:

Construction phasing will take place over the next 40 years.



XI. Maintenance

Bioswales:

- Yearly “spring cleaning” trim (prune woody shrubs and trees, cut herbaceous perennials to the ground as appropriate)
- Bioswales will be equipped with (cistern-fed) in-ground irrigation, which will only be utilized when 14 or more consecutive days have passed without a rain event of at least one inch, or during periods of 7 consecutive days or more without rain in which daily high temperatures have exceeded 100 degrees fahrenheit during at least two of those days.
- Minimum monthly checkups performed (from March through November) by university facilities staff to identify and troubleshoot problems including, but not limited to: drainage issues, problems with survival of plantings, branches which have fallen or are blocking pedestrian passage, significant intrusion of invasive plant species into planted swales, or other unsightly or hazardous conditions

- The above are guidelines, ; facilities staff are asked to adapt approaches to watering, maintenance, and (rare) fertilizer application when necessary

Regenerative Stream Conveyance:

- Inspect in-stream structures (riffles and weirs), outfall conveyance (step pool) structures, and stream channel for signs of scouring or degradation. This inspection must be performed yearly by a specialist, and interventions should be made conservatively. Particularly in the first few years, it is normal for the stream to go through restructuring. Rills on steeper slopes may be filled in with pea gravel, followed by wood chips.

Riparian Buffer:

- Yearly invasive inspection and removal (cut woody invasive vines at ground level, pull crawling invasives, uproot invasive shrubs when possible)
- Yearly arborist consult to verify health and stability of trees

Cistern

- Empty and disinfect if cistern comes in contact with floodwater
- Empty cistern if water sits unused for more than three weeks
- Inspect cistern yearly for buildup of sludge or other contaminants, as well as for visible structural issues.

Irrigation Systems

- Monthly inspection by University of Maryland Facilities Staff to identify leaks or other damage to equipment

Green Roof

- Minimum yearly inspection by facilities staff, during which time weeds will be removed (within reason), and any issues with drainage or planting survival will be followed up by a qualified specialist.

Artificial Turf Fields

- Turf must be swept every 2 weeks
- Turf will be installed with an irrigation system, and may be irrigated, as the university facilities staff see fit. Irrigating artificial turf is not strictly necessary, but doing so can increase longevity of the turf, cool the surface, and reduce injuries (mainly “rug burn”).
- Turf fabric must be replaced once every 10 years

XII. Cost Estimate

Discrete Item	Approx Capital Cost	Approx Annual Maintenance Cost
Green Roof - Basketball Practice Facility	$195,000	$60,000
Green Roof - Academic Building on Stilts	$1,000,000	$31,000
Bioswales & Terracing	$2,600,000	$15,000
Stream Restoration	$571,000	$5,000
Native Tree Plantings	$27,100	minimal
Underground Cistern	$15,000	$1,000
Floodable rec field	$2,700,000	$3,500
Multifunctional Recreation & Tailgating Field	$795,000	$7,000
Pedestrian Paths	$319,000	$1,450
Boardwalk	$1,650,000	$2,500
Pathway Lighting	$787,000	minimal
Green Pavement Marking	$361,000	minimal
5" Yellow Retroreflective Pavement Marking	$45,000	minimal
Bike Lane symbols Every 10’	$113,000	minimal
Educational Signage	$2,500.00	minimal
Total	**$11,180,600**	**$126,450**
New Building	Approx Capital Cost	
Parking Garage	$45,000,000	
basketball practice facility	$36,000,000	
New academic building on Stilts	$215,000,000	
Total	**$296,000,000**	

XIII. Funding

As a public state school, UMD has opportunities for funding from multiple sources, including private, federal, and state institutions. The Chesapeake and Atlantic Coastal Bays Trust Fund via the Maryland Department of Natural Resources funded the 2 million dollar restoration project for Phase 1 of Campus Creek Restoration, and could be a viable source for funding of continued restoration efforts. The Maryland Sea Grant is a state-wide grant awarded to projects that "demonstrate a clear link between coastal and marine science and conservation and restoration efforts in Maryland" (National Oceanic and Atmospheric Administration, 2020). The project team could partner with students and faculty in the marine science department at UMD to combine efforts into a single restoration project of Campus Creek.

Another funding opportunity is the Stormwater Stewardship Grants, offered by Prince George's County to fund "on-the-ground restoration and program activities that improve communities and water quality and engage County residents in the restoration and protection of local waterways" (Prince George's County, 2021).

Due to the location of the site within the Anacostia Watershed, stormwater management and ecosystem services on this site are vitally important for the health of the downstream Anacostia River and Chesapeake Bay. Future Flows is eligible for several grants through the Chesapeake Bay Program. Future Flows qualifies for the U.S. Environmental Protection Agency's (EPA) Small Watershed Grant Program, administered by the National Fish and Wildlife Foundation (NFWF) and primarily funded by the U.S. EPA Chesapeake Bay Program, which supports conservation projects that contribute to the health and protection of the Chesapeake Bay. Future Flows is also eligible for the Chesapeake Bay Stewardship Fund, "a partnership between the Bay Program and the National Fish and Wildlife Foundation to strategically invest in conservation actions to restore the Bay" (Chesapeake Bay Program, 2021).

In the past, alumni have made large private donations to specific programs at UMD, particularly athletics. A 220 million dollar renovation of Cole Field House was completed in 2020 and included two biology research facilities and a new indoor football stadium (The Diamondback, 2020). This project gives precedent that education, research, and athletics can be integrated into a single development project on campus. By integrating existing plans for a new basketball practice stadium and a new, innovative tailgating field into the Future Flows master plan, the team aims to show that large donations to the school for development purposes can prioritize green infrastructure. By tying Future Flows to school athletics, the team hopes to raise awareness of the vital need to protect Maryland's fragile ecosystems and for new development to be environmentally conscious.

XIV. Conclusion

Future Flows demonstrates the need to immediately redirect priorities and demonstrate a commitment to a sustainable future through design on campus. Drastic measures are necessary to rethink the way people and water move and flow through campus and plan for future flows. The UMD master plan shows expected development in the north district to focus on athletic and academic buildings. By consolidating parking and reevaluating transportation flows, Future Flows show the opportunities for stormwater improvements that can be found in unexpected places.As the university continues to expand; data shows that student enrollment is rising and new infrastructure will be needed to accommodate that growth. Development in the North District is inevitable and can lead to positive local and regional environmental, social, and economic changes by consciously incorporating green infrastructure and prioritizing sustainable choices that protect valuable natural resources, especially Campus Creek and Maryland's unique ecosystems.

References

[1]] *2021 cost to build a parking garage: Parking lot costs per square foot.* (2021, August 26). Fixx. Retrieved December 4, 2021, from https://www.fixr.com/costs/build-parking-garage.
[2] Chesapeake Bay Program. (2021). *Small watershed grants program.* Retrieved December 8, 2021, from https://www.chesapeakebay.net/what/grants/small_watershed_grants.
[3] *Cole Field House renovations will likely cost $55 million more than originally planned.* The Diamondback. (2020, August 27). Retrieved December 5, 2021, from https://dbknews.com/2019/09/29/cole-field-house-cost-55-million/.
[4] District Department of Energy and Environment. (2020, September 30). For a Cleaner Anacostia River - Anacostia River Sediment Project. Retrieved December 3, 2021, from https://doee.dc.gov/publication/cleaner-anacostia-river-anacostia-river-sediment-project.
[5] First Street Foundation. (2021). *Flood risk overview for Maryland.* Flood Factor. Retrieved December 9, 2021, from https://floodfactor.com/state/maryland/24_fsid.
[6] i-Tree Eco. i-Tree Software Suite v6.0. (n.d.). Web. Accessed 8 December 2021. http://www.itreetools.org
[7] Maryland Commission on Climate Change, 2021 Annual Report and Building Energy Transition Plan (2021).
[8] IPCC, 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In press.
[9] Maryland Department of the Environment. (2021, November 3). *State of Maryland - growing five million trees by 2030.* State of Maryland – Growing Five Million Trees by 2030. Retrieved December 7, 2021, from https://us.1t.org/pledge/state-of-maryland-growing-five-million-trees-by-2030/.
[10] Maryland Geological Survey. Physiographic Map of Maryland. (2021). Retrieved December 4, 2021, from http://www.mgs.md.gov/geology/physiographic_map.html.
[11] Maryland Department of Natural Resources. (2021). *Riparian Forest Buffer Initiative/Stream ReLeaf.* Retrieved December 4, 2021, from https://dnr.maryland.gov/forests/Pages/programapps/ripfbi.aspx.
[12] Maryland Department of Planning. (June 2011). PlanMaryland. Retrieved December 4, 2021, from https://planning.maryland.gov/Documents/YourPart/773/2011/MDP_PlanMarylandProgressReport.pdf
[13] Maryland State Police. (2021). *Maryland Statewide Vehicle Crashes.* Retrieved December 2, 2021, from https://opendata.maryland.gov/Public-Safety/Maryland-Statewide-Vehicle-Crashes-Vehicle-Details/mhft-5t5y.
[14] National Oceanic and Atmospheric Administration. (2020). *Program development funds.* Maryland Sea Grant. Retrieved December 7, 2021, from https://www.mdsg.umd.edu/program-development-funds.
[15] Nowak, D.J. 1995. Trees pollute? A "TREE" explains it all. In: Proceedings of the 7th National Urban Forestry Conference. Washington, DC: American Forests: 28-30.
[16] Prince George's County. (2021). Stormwater Stewardship Grants. Retrieved December 2, 2021, from https://www.princegeorgescountymd.gov/2837/Stewardship-Grant-Program.
[17] Prince George's County Planning Department , Plan 35- Prince George's 2035 Approved General Plan (2014). Retrieved December 9, 2021, from https://www.mncppcapps.org/planning/publications/BookDetail.cfm?item_id=279&Category_id=1.
[18] *Simple method - hydrocad stormwater modeling.* (n.d.). Retrieved December 9, 2021, from https://www.hydrocad.net/pdf/NY-Simple-Method.pdf.
[19] SustainableUMD. (2021). Food. Retrieved November 18, 2021, from https://sustainability.umd.edu/food.
[20] SustainableUMD. (2021.). Progress & commitments. Retrieved November 18, 2021, from https://sustainability.umd.edu/progress-commitments.
[21] The Spaces Between. (2020). *Momentum Magazine.*
[22]University of Maryland. (2011). UMD Facilities Master Plan, 2011-2020.
[23] University of Maryland Department of Transportation. (2021). Incentives. Retrieved November 18, 2021, from https://transportation.umd.edu/sustainable-transportation/incentives.
[24] World Recycling Surfacing Group. (n.d.). *Life Cycle Cost Analysis: Synthetic vs Natural Turf.* PolyTurf: Covering New Ground. Retrieved December 7, 2021, from https://cms1files.revize.com/denvillenj/docs/Misc/Artificial_Turf_LifeCycle_Costs.pdf.
[25]University of Maryland School of Public Health. (2021). *Healing and Preserving the Health and Well-Being of Every Person in Nature* . NatureRx@UMD Laboratory. Retrieved December 10, 2021, from https://sph.umd.edu/research-impact/laboratories-projects-and-programs/naturerxumd-laboratory.
[26] Prince George's County Department of Public Works and Transportation. (2021). *The Importance of Vision Zero.* What is Vision Zero Prince Georges? Retrieved December 10, 2021, from https://www.princegeorgescountymd.gov/3183/Vision-Zero-Prince-Georges.